defining sleep?

- mentation – report on content upon arousal

behavior

arousal thresholds/stimulus detection – (i.e., attention)

electrophysiology

- EEG – electroencephalogram (cortical LFPs)
- EMG – electromyogram (recording of muscle potentials)
- EOG – electrooculogram (recording of eye movements)
the frequency and vividness of dream content is much higher in REM sleep than in non-REM sleep
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arousal thresholds/stimulus detection

electrophysiology
- EEG – electroencephalogram (cortical LFPs)
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monitoring behavior works sometimes, but one can certainly be awake and immobile for an extended period of time.
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arousal thresholds/stimulus detection

electrophysiology
- EEG - electroencephalogram (cortical LFPs)
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arousal threshold/stimulus detection may work reasonably well, but the waking state may also be accompanied by serious inattention… and arousal from sleep depends on the meaningfulness of the stimulus.
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arousal thresholds/stimulus detection

electrophysiology
- EEG - electroencephalogram (cortical LFPs)
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extended immobility is associated with alterations in cortical EEG patterns
the basic patterns of cortical EEG/LFP activity in the cerebral cortex closely track sleep depth as assessed by arousal thresholds.
science settles (sort of) on a combinatorial approach to defining sleep

‘sleep’ in insects, defined by monitoring motion and arousal threshold, is not associated with the patterns of LFPs observed in birds and mammals.
So…sleep may be reasonably well defined by a set of criteria that include measures of behavior, arousal thresholds, and electrophysiology.

But…using such a combinatorial scheme to define sleep, we still have the following problems:

1. two *almost* entirely different states of sleep in the mammal (REM and non-REM sleep) are defined

2. different definitions of sleep for insects, reptiles, and mammals

3. birds and mammals may be half asleep and half awake
to slow-wave or not to slow-wave? – the patterning of LFP activity within the thalamocortical system is largely determined by brainstem and hypothalamic neuromodulatory neurons and brainstem reticular formation neurons via their projections to the thalamic reticular nucleus.
depressed activity of brainstem reticular formation neurons closely follows the production of spindle and slow-wave cortical EEG events

REM sleep is characterized by phasic events generated by bursting of brainstem reticular formation neurons – these ‘events’ may take the form of eye movements, twitches of non-axial musculature, and/or LFP events in the lateral geniculate nucleus that are called ‘PGO waves’.

Steriade et al., 1990, J. Neuroscience
PGO spikes can also be elicited in waking states, but primarily in response to surprise stimuli (such as a hand clap) that attracts attention in the form of an orienting response.
the mysterious echidna, a member of the monotreme order of mammals

at first thought to be the only mammal to lack REM sleep

later, Siegel shows that echidna non-REM (slow-wave) sleep is punctuated by REM-like brainstem burst events